Ex/Prod/T/213/41/2017(S)

BACHELOR OF PRODUCTION ENGINEERING EXAMINATION, 2017(Supplementary)

2^{nd} Year, 1st Semester

DEFORMATION OF SOLIDS

Time: 3 hours. Full Marks 100

Answer any FIVE questions, taking any THREE from group-A and any TWO from group-B.

All parts of a question (a, b etc) should be answered at one place.

All the dimensions in the figures are in centimeters unless indicated otherwise.

GROUP—A

1(a) The frame shown in Fig.1 (a) is made up of 10 cm x 10 cm square wood posts for which the allowable stress in shear parallel to the grain is τ_w =7 kg/cm^2 while that in compression perpendicular to the grain is σ_w = 28 kg/cm^2. The vertical post is pinned to the sill at its lower end.

(i) Calculate the minimum safe values of the dimensions a, b and c.

(ii) What is the required diameter d of the pin, if the bearing pressure between the wood and pin at the bottom end of the vertical post is 14 kg/cm^2? Assume the width of the bearing area in this case is projected diameter of the pin.

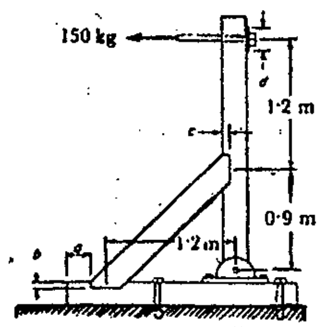

Fig.1 (a)

(b) A rigid bar AB is hinged at A and supported in a horizontal position by two identical vertical steel wires as shown in Fig.1 (b). Find the tensile forces S_1 and S_2 induced in these wires by a vertical load P applied at B as shown.

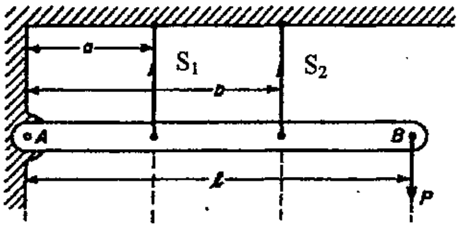

Fig.1 (b)

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2(a) Consider a vertical bar of uniform cross-section with a flange at the lower end as shown in Fig. 2(a). Weight 'W' is released from a height 'h' and falls freely along the bar until it strikes the flange. Determine the maximum deflection 'δ' of the bar and also calculate the maximum stress

(i) when 'h' is large compared to the elongation of the bar &

(ii) when 'h' is zero.

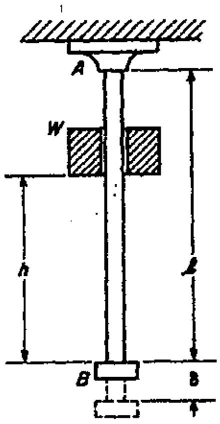

Fig.2(a)

(b)For the simple structure shown in Fig. 2(b), member BC is a steel wire having diameter d = 3 mm and member AB is a wood strut of 2.5cm-square cross-section. Calculate the horizontal and vertical components of the displacement of point B due to a vertical load P = 200 kg acting as shown. For steel, $E_s = 2\times10^6$ kg/cm^2 for wood, $E_w = 10\times10^4$ kg/cm^2.

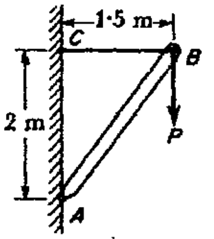

Fig.2 (b)

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3(a) Show that bending stress can be expressed as

$$\sigma = My/I$$

Where each symbol holds its usual significance.

(b) A shaft of diameter *d*, bent in the form of a semicircle AB of radius *R*, is built-in at A and loaded at B by a force *P* acting perpendicular to the plane of the ring as shown in Fig.3 (b). Thus any cross-section C of the ring is subjected to both bending and torsion. Assuming that *d* is small compared with *R* so that the theory of bending of straight bars may be used, find the value of Φ for which the principal stress σ will be a maximum.

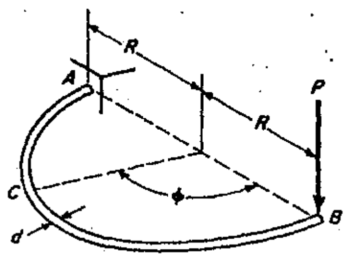

Fig.3 (b)

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4 (a) Show that the angle of twist for a shaft subject to torsion, can be represented by the following relation

$$\Phi = TL/GJ$$

Where the symbols have the usual meaning.

(b) A solid steel shaft of diameter d= 6mm fits loosely inside a hollow steel shaft of inside diameter $d = 6$ mm and outside diameter $d_1 = 9$ mm as shown in Fig. 4(b). A pin AA prevents relative rotation between the ends of the shafts at the left. Pinholes at the right are initially at right angles to each other as shown. The two shafts are now twisted in opposite directions until the pinholes at B line up and a pin BB is then inserted. How much strain energy will be locked in the system if l= 250 cm? Assume $G = 84\times10^4$Kg/cm^2.

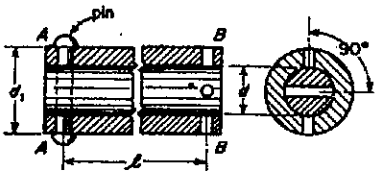

Fig.4 (b)

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5(a) Construct the complete shear force and bending moment diagram for the beam shown in Fig.5 (a). Also determine the maximum bending moment and the point of contra-flexure.

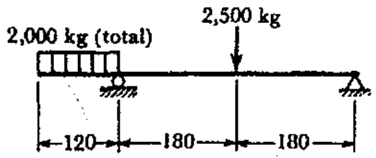

Fig.5 (a)

(b) For a rectangular element shown in Fig. 5(b), the following numerical data are given σ_x= 100 kg/cm^2, σ_x= 75 kg/cm^2 and τ_{xy}= 50 kg/cm^2. Determine

(i) The values of σ_x and τ on the plane whose normal is defined by $\varphi = 30°$.

(ii) The magnitude and direction of the principal stresses σ_1 and σ_2.

(iii) The stress component and planes on which shear stress is the maximum.

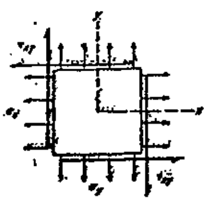

Fig.5 (b) 10+10

GROUP—B

6 An inverted hemispherical shell of mean radius $R = 1.5$ m and wall thickness $t =$ 0.025 cm is bolted to a horizontal slab and filled with water (specific weight $w =$ 1 gm/cm^3) to a depth $h = 1.2$m as shown in Fig. 6. There is a small air hole at the top of the shell to equalize inside and outside air pressure. Calculate the principal membrane stresses σ_1 and σ_2 for an element A of the shell 0.3 m above the base.

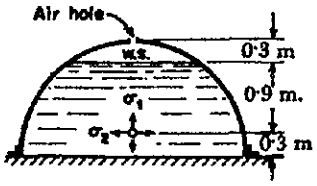

Fig. 6 20

7(a) A simply supported prismatic beam carries a uniformly distributed load of intensity w over its span l. Develop the equation of the elastic line and find the maximum deflection at the middle of the span.

(b) A solid steel shaft with a flywheel at one end rotates at constant speed $n = 120$ rpm, Fig. 7(b). If the bearing A suddenly freezes, what maximum shear stress τ will be produced in the shaft due to dynamic effects? Assume $\ell = 1.5$ m, $d = 5$ cm, the weight of the flywheel $W = 50$ kg, and its radius of gyration $i = 25$ cm, G $= 84\times10^4$ Kg/cm^2.

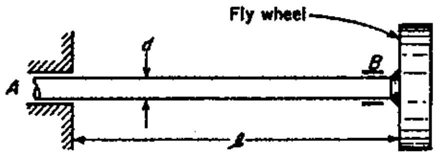

Fig.7(b)

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8 (a) A simply supported beam carries a linearly varying transverse load as shown in Fig. 8(a). The intensity of load at each end of the beam is w_o. Develop general expressions for V_x, and M_x, at a cross-section distance x from support A. At what value of x will the bending moment be a maximum? What is the shear force at the middle cross-section of the beam?

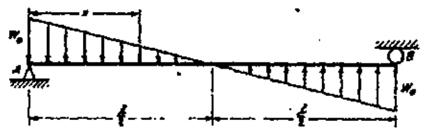

Fig. 8(a)

(b) A twisted steel clothesline wire of length L has cross-sectional area A and modulus of elasticity E in tension. This wire is stretched horizontally between two fixed points A and B, but without appreciable initial tension. A load P is then suspended from the mid-point C of the line. Find the vertical deflection of point C, assuming that this deflection is small compared with the length L of the clothesline.

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